Radio Construction and Repair Work

LESSON 7X3

SPRAYBERRY ACADEMY of RADIO

ESTABLISHED 1932

PUEBLO, COLORADO

RADIO CONSTRUCTION AND REPAIR WORK

How to Make Tests with Your Sprayberry Radio Receiver

LESSON No. 7X3

Before starting the work described in this lesson, it is necessary that you complete all of the preceding work in lessons 7X-1 and 7X-2. In other words, your receiver should be functioning normally according to instructions.

The previous 55 demonstrations have dealt with construction and observation of effects. The remaining demonstrations to be described in this lesson relate to testing and repair.

One of the most useful test units available to the radio man is some form of *continuity tester*. A test of continuity means just what the name implies—that is, an indication of continuing completeness. As applied to radio or electrical circuits, a continuity tester will indicate if a circuit is complete and continuous (*closed*) or if it is *open*.

Every continuity tester, no matter what its form, must have a source of energy independent of the circuit it is to test, to operate its indicator. The indicator is the device which indicates the continuity or lack of it in a circuit. The source of operating energy is usually electricity. This may be obtained from a battery, from the electrical power line, from an operating radio set or, in fact, from almost any source of electricity.

The indicator must be chosen to fit the type of operating energy—that is, D.C., A.C., low voltage, high voltage and whether it is a current or voltage operated device.

When it comes to a choice of indicator, a suitable electrical meter is much to be preferred because of its convenience and sensitivity. Almost any type of meter may be used as a continuity tester although the more current a meter draws for full scale deflection, the less its sensitivity. In general, a meter drawing more than 5 milliamperes should not be used as a continuity tester, particularly in high resistance circuits. An O-1 milliammeter is the most commonly used meter for continuity testing, although one drawing less current will be more sensitive and is often used.

To use a milliammeter as a continuity tester, a resistance must be connected in series with the meter to limit the current flow to full scale deflection of the meter — it then becomes an ohmmeter as well. A voltmeter usually requires no external resistance because it already has an internal resistance to protect it. A voltmeter range for continuity testing should be so

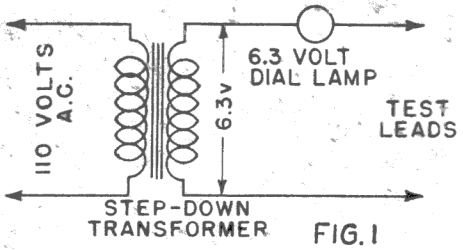


FIG. 1

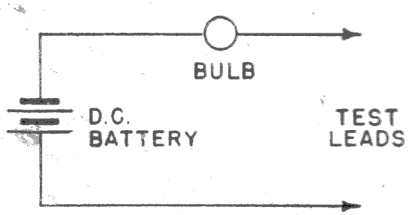


FIG. 2

chosen that it just exceeds the value of the voltage source. Thus, if a 4.5 volt battery is being used, a voltmeter range of 5 volts or more should be chosen.

If you can get a meter, we recommend that you use it as a continuity tester. If in doubt as to how to connect a given meter for use as a continuity tester, write us, giving the name, model number, type (A.C. or D.C.) and ranges the meter employes, and we will be glad to give you proper directions for its use.

If you do not have access to a meter as a continuity tester, do not let it worry you. Several other systems may be employed most satisfactorily.

A simple device of this type is the neon bulb. A high voltage D.C. supply in series with the neon bulb is also required. This D.C. voltage is most easily obtained from the power supply of the radio set you get with your Sprayberry training although any other high voltage D.C. supply will be satisfactory. Before going into the details of this, consider a continuity tester in more detail.

Such a tester may be any electrical device as long as it will indicate the electrical completeness or lack of it in a circuit. Such testers are known as low and high sensitivity continuity testers. One requiring relatively high current for its operation is a low sensitivity tester. Examples of this type are the low voltage radio pilot or dial lamps, electrical buzzer, 110 volt house lighting lamps, milliammeter or microammeter type of ohmmeter, headphones, electric eye tube, neon bulb, etc. In other words, the less current an indicating device needs for its operation when used in testing high resistance, the better continuity tester it makes for radio circuits. It is for this reason we recommend the neon bulb type of tester (in lieu of a meter) although there are special cases where a low sensitivity tester is useful (when it is desired that a circuit carry high values of current).

Figures 1 to 4 show four examples of the low sensitivity type of

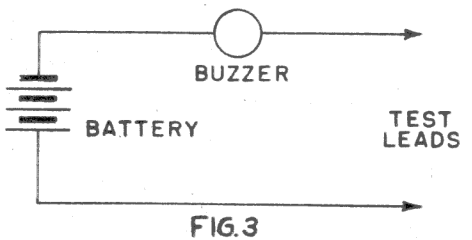


FIG. 3

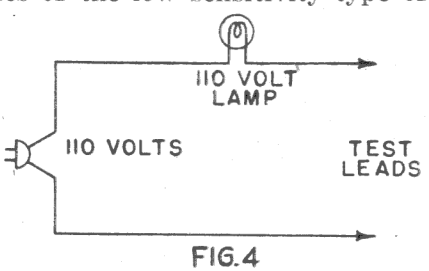


FIG. 4

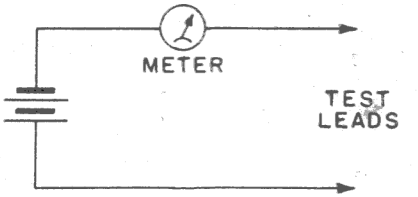


FIG.5

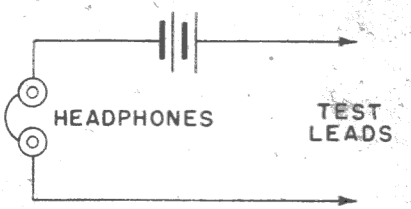


FIG.6

continuity tester. Figure 1 shows an ordinary step-down transformer such as a 6.3 volt filament transformer. The secondary of this is in series with a 6.3 volt radio pilot lamp. Figure 2 shows a flashlight bulb in series with a flashlight battery. A similar circuit is shown in Fig. 3 with a suitable battery in series with a buzzer, such as the door bell type. Figure 4 shows an ordinary house lighting bulb in series with the 110 volt A.C. or D.C. power line.

Figures 5, 6 and 7 show three high sensitivity types of continuity testers. In Fig. 5 is shown the usual meter in series with a voltage source—this is commonly called an ohmmeter because its scale is graduated in values of resistance. In Fig. 6, a pair of headphones is in series with a battery, and in Fig. 7, a neon bulb and a 100,000 ohm resistor is in series with a voltage source. The latter will indicate through resistances up to 50 megohms.

Note particularly that all the circuits of Figs. 1 through 7 have three things in common: (1) a source of operating voltage, (2) an indicating device and (3) a pair of test leads. The test leads may be of the ordinary commercial type such as is usually obtainable from any radio parts jobber. However, you may use a pair of ordinary insulated wires with phonograph needles at the ends if commercial leads are not available. Regardless of the type of indicator used, make sure that its operating voltage does not exceed the safe voltage limit of the indicating device. For instance, in Fig. 2 do not use a 6 volt battery in series with a 3 volt flashlight bulb, etc. The reason for this is that with little or no resistance across the test leads, the full force of the operating power is applied to the indicating device. Thus, with excess operating voltage your indicator is likely to be damaged.

A continuity tester operates on the principle that with the test leads shorted (*touched together*), the indicator will denote a flow of current. *But remember, this flow of current must be from the power source which operates the indicator of the continuity tester. It should not indicate a current flow from the power source in the radio set you are working on. When using the continuity tester of the types described in Figs. 1 to 7, the radio set must be disconnected from its power source and all tubes*

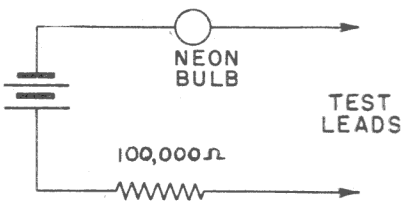


FIG.7

of the receiver should preferably be removed from their sockets.

The type of continuity tester you use will, of course, determine what you are to observe to indicate continuity. For instance, in Figs. 1, 2 and 4 the lamps or bulbs will light when the test leads are touched together. In Fig. 3 the buzzer will emit sound when the test circuit is completed. In Fig. 5, with the test leads touched together, the meter needle will move. In Fig. 6 the headphones will click (sound) and in Fig. 7 the neon bulb will light.

The indicators in these various test circuits will produce evidence (light, sound, etc.) of a complete circuit when the test leads are shorted. *With one test lead placed at one point* in a radio circuit under test and *the other test lead at another point* in the same circuit, the continuity tester will show whether or not the circuit is complete between the two test leads. This is a most important principle *and one which can be made very useful.* However, in making use of this principle, the radio man must be careful to take into consideration the resistance of the circuit under test and the type of radio parts connected to the circuit.

In general, with a circuit consisting of wire connections only, any of the continuity testers shown in Figs. 1 to 7 may be used satisfactorily. However, as more and more resistance is included in the test circuit, the current from the tester circuit will become less and less with the result that when a certain critical resistance value is reached the tester will no longer indicate. When this happens, the tester is no longer useful for a high resistance circuit, and you must resort to a tester with higher sensitivity. Thus, you might as well use a high sensitivity tester to begin with, for then you can take care of all circuits with one test unit. The circuit of Fig. 7 is, therefore, recommended. The use of the 100,000 ohm resistor in Fig. 7 is not necessary if the neon bulb you use has its own internal resistance. More directions for this type of continuity tester will be given later.

BASIC TEST PRINCIPLES

Next consider some basic testing principles — principles which apply no matter what you are testing and regardless of the type of continuity tester employed. It is safe to assume that in 99% of the cases, the average radio set on the American market has the proper design—there are some few exceptions to this rule, but they are of such minor consequence that you do not have to worry about them. If you recognize and accept this principle, you do not need to worry about part values, etc., because if everything else is normal, you can assume part values are also normal.

Now consider the radio circuit itself. Basically, it contains nothing more than units of resistance, inductance, capacity and vacuum tubes. No matter how complicated the circuit, it can be resolved to these four basic items. Looked at in this way, a radio circuit is a relatively simple device. It is most important for you to remember this because it will serve you well. Keep in mind in the following discussion that the basic principles

outlined are for your guidance when using a continuity tester.

Granted a radio circuit involves nothing more than resistance, inductance, capacity and vacuum tubes, it is well to remember how these react to the two basic forms of electrical power; namely, A.C. and D.C. Resistance will pass both A.C. and D.C., the current value being limited only by the resistance value.

Inductance (which includes all wire leads and all forms of coils) will also pass both A.C. and D.C. But remember this important fact; inductance does not react alike to both A.C. and D.C. For A.C. inductance offers both *reactance and resistance.* These two terms (reactance and resistance) are usually combined, and the effect of both of them is called IMPEDANCE. Remember, then, for *alternating current* (A.C.) inductance offers impedance to the flow of current, and the value of the current is limited by the value of the impedance and frequency (for a given value of voltage). For this reason an A.C. source is not recommended to operate a *continuity* tester of any kind. Remember, too, in a radio circuit, an inductance may, and often does, carry both A.C. and D.C.

For *direct current* (D.C.) inductance acts similar to an ordinary resistance. From a D.C. continuity viewpoint, simply consider an inductance (no matter what its form) as you would any other resistance.

Next consider capacity (condensers in many forms). This includes all forms of mica and paper dielectric condensers. These also have impedance but not in the same sense as inductance. While inductance will conduct D.C., condensers of the type described here will not (if they are in good condition). Every condenser, no matter how good, has a minute D.C. leakage, but until this assumes extreme values of current, this D.C. leakage of current may be neglected entirely. Therefore, remember this important fact—for all practical purposes, a good mica or paper condenser will not pass D.C. If it does, it is defective. When testing condensers for continuity remember that they are not supposed to show a *closed circuit.*

For A.C., capacity will, in effect, conduct current. The amount will depend on the impedance of the condenser and other factors. For practical test purposes you do not need to know the value of A.C. through a condenser, but, if it passes D.C., you do want to know it.

One other common form of capacity is the electrolytic condenser. It is found in two forms: (1) using a liquid dielectric (called the wet type) and (2) using a thick paste form of dielectric (called the dry type). Both forms react alike to A.C. and D.C. An electrolytic condenser (of the type used in radio sets) will not operate properly when used on A.C. only. It is used in circuits having a high content of varying current but a D.C. is necessary to keep the condenser polarized and in operating order. Such condensers, therefore, have polarity, and the positive of the condenser must be connected to the positive or high potential side of the circuit with the negative of

the condenser going to the negative or low potential side of the circuit (see your other Sprayberry lessons for further details). As compared to other types of condensers, the electrolytic types have high D.C. leakage current, but, due to large values of capacity, the normal leakage current is not bothersome and is neglected. When an electrolytic condenser passes abnormally large values of D.C. under normal voltage values, it is no longer useful and must be discarded.

The remaining basic unit in a radio set is the vacuum tube. Several different types are used in one set. They are designed to accomplish different things, and, therefore, they do not all react alike. Assuming everything in the set is normal, there are various way to determine the condition of tubes. The basic fact here is that, with all other parts in the set normal, the substitution of a good tube for a bad one will correct the trouble. Tubes should always be tested on a manufactured tube tester when one is available. When a tube tester is not available, then the substitution method should be employed — using a known good tube to check on the performance of a tube in doubtful condition. More information will be given on this under another demonstration.

Dmonstration No. 56

HOW TO MAKE A LOW SENSITIVITY CONTINUITY TESTER

The pilot light of your radio set will make an excellent *low sensitivity* continuity tester. It may be used to test all types of

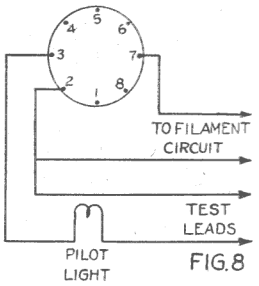


FIG.8

circuits *having low resistance.* This will include all circuit wiring (through switch contacts when they are closed) and all other parts having negligible D.C. resistance. To arrange the pilot light as a continuity tester, first refer to Fig. 1 of lesson 7X2 and note how the pilot light is connected. Then arrange the circuit of the pilot light as in Fig. 8. Note the pilot light circuit is opened and a pair of test leads are inserted in series with it. The test leads may be of the standard type (which you can get from most radio jobbers) with spring clips attached to the ends (for clipping to the pilot light circuit). If standard test leads are not available, use two 24 to 36 inch insulated wires as test leads. In this case, solder one end of the wires directly to the pilot light circuit as shown by the connections of Fig. 8. Then cut off about ½ inch of insulation from the other ends of the wires. Next scrape or sandpaper the bare wire until it is bright and clean. Then apply hot solder to these two wire ends. Make sure the solder adheres to the wire (all around it) up to the point where the insulation begins. When the solder cools, it will stiffen the ends of the wire leads and this will make for easier connection to the circuit you want to test.

When you have set up the arrangement shown in Fig. 8, check over all your connections to see that you have followed directions. Make sure your test leads are in series with the pilot light and not in parallel with it—a parallel connection will short the pilot light.

Next, separate the ends of your test leads so that they do not touch. Connect your receiver to the power line, turn on the switch and allow it to come to operating temperature. Note the pilot light does not light. Next touch the ends of your test leads together and note that this time the pilot light does light. Thus you have a *low sensitivity continuity tester.* By placing one test lead at one point along a circuit and the other test lead at some other point along the same circuit, you can prove that it is not open. If the pilot light glows, the circuit is complete and if it does not glow or light, you have proof it is open or incomplete. This can be a very useful test, as will be brought out later in other demonstrations. While this test is being made on a radio set it should be *ungrounded.*

Demonstration No. 57

HOW TO MAKE A HIGH SENSITIVITY CONTINUITY TESTER

It was mentioned in connection with Fig. 7 that the most useful continuity tester (except the meter type) was a neon bulb in series with a resistor and voltage source. Such a test unit can be arranged using the power supply of your radio set as the operating voltage. See Fig. 9.

To make this a permanent tester, it is suggested that you mount all the required parts on a small wood block about 4 inches square and about ½ or ¾ inch thick. You will need a neon bulb, a 100,000 ohm resistor and a pair of test leads. Your neon bulb may include a resistor in its base. If the one you get is rated at about 120-125 volts no external resistor will be required. Simply let a wire circuit replace the resistor in Fig. 9. The neon bulb is not critical. Use any size available from ⅛ to 1 watt. It may have a screw or bayonet type base or it may be the unmounted kind with a pair of wire leads at the base. If it has a screw or bayonet base, be sure to get a socket to fit it and make your connections to the socket terminals. If you have trouble in getting the screw or bayonet type, get the unmounted type with wire leads and make your connections to these leads. In this case the external 100,000 resistor will be required. Figure 10 shows one type of circuit you can employ. In making your connection of the test lead to the 100,000 ohm resistor, secure the resistor to the board so a pull on the test lead won't move the resistor. The same principle applies to the other end of the circuit

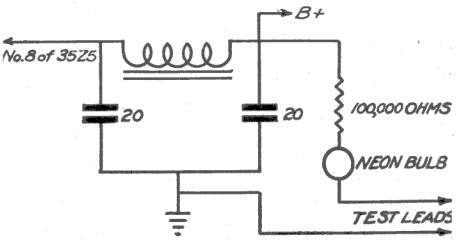


FIG. 9

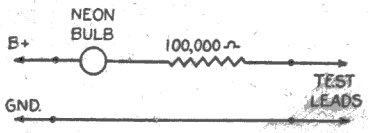


FIG. 10

where the B+ wire connects to the neon bulb. Arrange it so that an accidental pull on the wire will not disturb the neon bulb.

An easy, convenient way to avoid undue pull on the neon bulb and 100,000 ohm resistor by the wire leads is to arrange four binding posts or tip jacks to receive the connecting leads. The large dots in the wire leads of Fig. 10 show how tip jacks or binding posts may be used for this purpose. Mount the tip jacks or binding posts on your wood block and connect wire leads to these when you use your continuity tester.

The two wires marked B+ and Gnd. of Fig. 10 *are to be connected to your radio set to obtain operating power for the continuity tester.* Connect the B+ lead to a point in Fig. 1 of lesson 7x2 which corresponds to the B+ terminal of the 20 mfd. output condenser. See Fig. 9. This can be made directly to terminal 4 of the 35L6 tube or to any other point common to this circuit. The Gnd. wire may be connected to a convenient part of the receiver chassis.

With this set up (Fig. 10) made, turn on your receiver and allow it to reach operating temperature. Next short or touch your test leads together. When this is done, note the neon bulb should light or glow. Thus, you have an excellent high sensitivity continuity tester which may be used to test circuits for opens and shorts. You can also determine the condition of the resistors, condensers, coils, switches, vacuum tubes filament opens) and make many other tests.

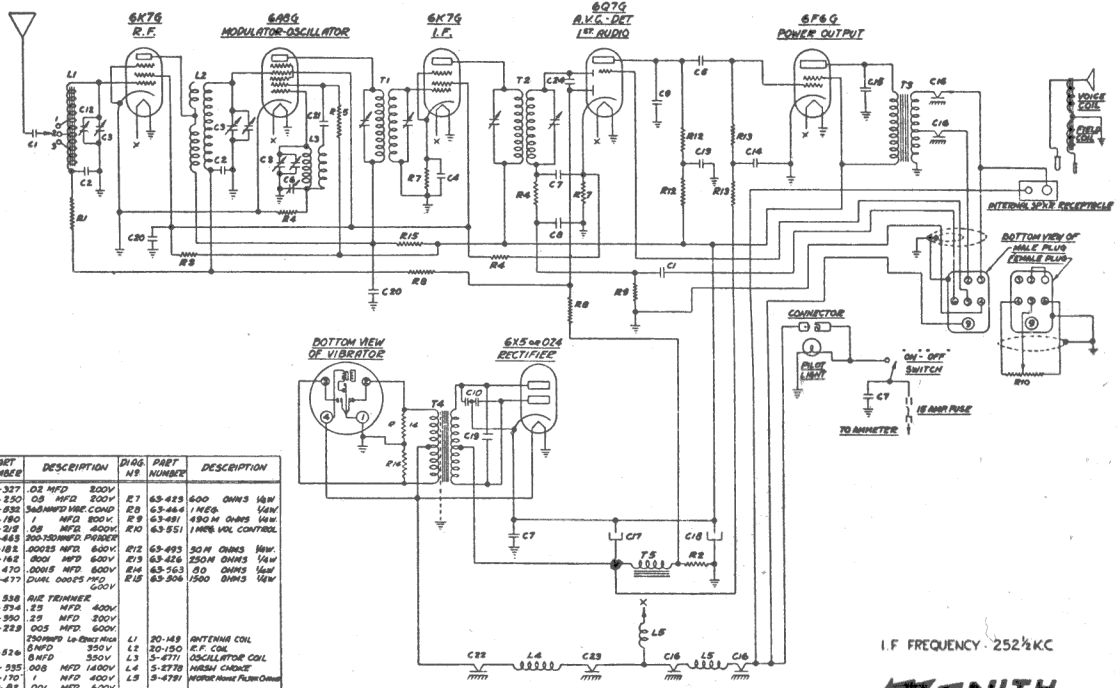
Demonstration No. 58

HOW TO TEST RESISTORS FOR CONTINUITY

The various tests which can be made with your continuity tester may be applied to any radio set. In describing how these tests should be made, it is necessary to select a radio receiver as an example. For this purpose, the Zenith Model 6B193 (chassis 5637) has been selected which is a 6-tube automobile radio receiver. Its circuit is shown in Fig. 11. *The tests to be described apply to all other types of radio sets regardless of make or model number.*

First, consider the resistors. As explained in your lesson S-14 there are three conditions you need to check for in resistors. These are an open, short and ground. Opens are the most common failure (result of burn out). An internal short rarely, if ever, occurs although circuits external to a resistor can short it. A ground can come about through failure of some other part or be caused by a resistor touching the chassis, but this type of trouble is also rare. So for the most part, you will be checking for an open or burned out resistor. Referring to Fig. 11, assume you have this or a similar receiver to test. To establish the condition of the resistors, use the circuit of Fig. 10 obtaining voltage to operate the neon tester from your receiver.

The receiver under test must be disconnected from its operating



DIAG. NO.	PART NUMBER	DESCRIPTION	DIAG. NO.	PART NUMBER	DESCRIPTION
C1	22-327	.02 MFD 200V	R7	63-423	600 OHMS 1/2W
C2	22-250	.05 MFD 200V	R8	63-444	1 MEG. 1/4W
C3	22-832	3-8 MMFD VAR. COND	R9	63-481	450 M OHMS 1/2W
C4	22-180	.1 MFD 200V.	R10	63-551	1 MEG. VOL CONTROL
C5	22-218	.08 MFD. 400V			
C6	22-465	200-750 MMFD. PADDER			
C7	22-182	.00025 MFD. 600V.	R12	63-493	30 M OHMS 1W.
C8	22-162	.001 MFD 600V	R13	63-426	250 M OHMS 1/4W
C9	22-470	.0015 MFD. 600V	R14	63-563	80 OHMS 1/2W
C10	22-477	DUAL .00025 MFD. 600V	R15	63-506	1500 OHMS 1/2W
C12	22-338	R.F. TRIMMER			
C13	22-334	.25 MFD. 400V			
C14	22-350	.25 MFD. 200V			
C15	22-223	.005 MFD. 600V.			
C16		250 MMFD Lo-Effect Mica	L1	20-149	ANTENNA COIL
C17	22-826	8 MFD 350V	L2	20-150	R.F. COIL
C18		8 MFD 350V	L3	5-4771	OSCILLATOR COIL
C19	22-335	.006 MFD 1400V	L4	5-2778	HASH CHOKE
C20	22-170	.1 MFD 400V	L5	5-4791	MOBILE HUMMER FILTER CHOKE
C21	22-82	.01 MFD. 600V			
C22	22-539	.5 MFD 200V			
C23	22-466	.5 MFD. 200V			
C24	22-289	.00005 MFD 600V			
			T1	95-392	1ST I.F. TRANSFORMER
			T2	95-393	2ND I.F. TRANSFORMER
			T3	95-397	OUTPUT TRANSFORMER
			T4	95-390	POWER TRANSFORMER
			T5	95-396	POWER CHOKE
B1	63-500	240 M OHMS 1/2W.		190-9	VIBRATOR
R2	63-507	60 OHMS 1/2W		49-170	DYNAMIC SPEAKER
R3	63-494	13 M OHMS 1W.			
R4	63-490	48 M OHMS 1/2W.			
R5	63-512	19 M OHMS 1W			

I.F FREQUENCY 252½KC

ZENITH AUTO RADIO

MODEL-6M192 CHASSIS 5637

ZENITH RADIO CORPORATION
CHICAGO, ILL.,

FIG. 11

power (storage battery, 110-volt line, etc.). If a resistor employs a series connection, all you need to do to test it is to place your test leads across it. This would apply to such resistors as R1, R2, R3, R4, R5, R8, etc., of Fig. 11. The method does not apply, however, when resistors have other parts connected across or in parallel to them. For instance, the R7 resistor in the cathode lead of the 6Q7G tube has a condenser (C4) across it. Before making a test on this or a similarly connected resistor, the condenser across it should first have one of its terminals disconnected to remove the parallel path. The test may then be made on the resistor as usual.

If the resistor under test is normal, the neon bulb will glow, its intensity being limited by the resistance value of the resistor under test. If there is no glow, the resistor is open or burned out and must be replaced.

The test need not be limited to one resistor. For instance, any number of resistors in series may be tested in this way. Thus, the two R12 resistors in the plate circuit of the 6Q7G tube may be tested at one time. If the neon bulb glows, both resistors are all right, but if it fails to glow, one or both resistors are open, and you should make a test on each to find out whether one or both are at fault. In making these tests, be sure to watch for parallel circuits.

Demonstration No. 59

HOW TO TEST CONDENSERS

Condensers also need to be checked for shorts and opens. A good condenser should prevent the passage of D. C.. although it will allow an A. C. or varying current to pass to a degree, depending on the capacity value and the frequency.

At this point it is necessary to remember some fundamental effects when testing condensers with a neon bulb in series with a high D. C. voltage. A solid type of condenser dielectric, such as used in ordinary paper and mica type condensers, will, if in normal condition, cause the neon bulb to flash on and off at a rate depending on the capacity value. When the condenser is first connected to the test circuit, there will be an initial flash (flash of light then cutting off) of the neon bulb. The bulb will then continue to flash at a regular rate as long as the condenser is left connected in the test circuit. The larger the capacity value (.5 mfd. to 10 mfd.), the less frequent will be the bulb flash. On the other hand, from .5 mfd. to very small values (up to .0005 mfd. or smaller), the bulb flashes will increase in frequency until the higher limit is reached where the bulb will appear to be continuously lighted. All this refers, of course, to a normal condenser.

An open condenser will not show an initial charging flash, nor will the bulb light at any time (it may show a very faint glow but this will be due to leakage across the condenser terminals). An intermittent condenser may or may not show an initial charging flash or again the bulb will glow infrequently and will, eventually (if left connected in the test circuit long enough—usually 5 to 10 minutes), go out altogether. Such a conden-

ser or one with an internal high resistance short will cause the bulb to light continuously but at a reduced glow in intensity if there is a high resistance short. Condensers showing this effect should be discarded and replaced.

For electrolytic condensers, the neon bulb will light continuously at slightly less than full brilliance. (Be sure to observe polarity when testing electrolytics). This applies to both the high and low voltage types (it does no harm to test low voltage electrolytics by this method when the condenser is only connected in the test circuit for a moment. To test an electrolytic condenser, connect it to the test circuit just as you would any other condenser, but while it is connected and still under test, short the condenser terminals with a screw driver blade. This should produce sparks and the neon bulb should increase in brilliance. If there are no sparks and if the neon bulb does not increase at the instant the short is made, then the condenser is shorted and should be replaced. If there is no initial charging flash and if the neon bulb does not react as described for a normal condenser, then the condenser is open and should be replaced.

When testing very small value condensers, the neon bulb will appear to be lighted continuously because the flashes will be so frequent. The light, however, will be at less intensity than when the test leads are simply shorted. Thus, from this you can judge if the condenser is all right. On the other hand, if the bulb does not light, the condenser is open, and if it lights to full brilliance, the condenser is shorted.

In Fig. 11 and in similar circuits there are many condensers which may short. They are also likely to become open but the more common trouble is a short, wherein the internal foil or plate shorts through the dielectric to the opposing plate or plates. When this happens, the unit no longer functions as a condenser, but rather acts like a resistor depending on the degree of the short. The neon bulb continuity tester will show up these conditions every time if the foregoing instructions are followed.

We do not recommend testing condensers with their terminals connected to the circuit. This procedure is all right for an experienced radio man with sensitive meters but the beginner should disconnect at least one of the condenser terminals before making tests.

In Fig. 11 and in similar circuits condensers which by-pass and filter B+ circuits are most likely to cause trouble. Thus, if you have a situation where little or no voltage is applied to plate and screen grid circuits, check the circuits involved for *open resistors and shorted condensers*. To test any condenser by the foregoing method, disconnect one of its terminals and apply the test leads as directed.

Demonstration No. 60

CIRCUIT CONTINUITY TESTING

The elements of continuity testing have already been covered with respect to individual parts. However, there are times when it is desirable to test lengthy circuits from

from the output of the power unit to the tube socket terminals. This is called *circuit continuity testing.* Often this method will isolate a defect to a given circuit, and then tests must be made on the individual parts of the circuit to locate the actual defect.

A quick way to test the continuity of plate and screen grid circuits of such receivers as the one shown in Fig. 11 is as follows: Connect one of your test leads to the cathode of the rectifier tube. Then touch the other test lead to the plate of the 6K7 RF tube. If the neon bulb lights, it indicates a complete circuit. The test includes the RF winding in the plate circuit and R-15, thus proving that neither they nor the wiring is open. A test from the screen grid terminal of the same tube will establish the condition of R3 and its associated wiring. A test from the plate of the 6A8G tube will establish the condition of the primary winding of T1, R15 and the circuit wiring. A test from the anode grid (pin No. 6) will check the condition of R5 and a test from the screen grid of the 6A8G (pin No. 4) will check the common screen grid circuit through R3. If the test lead at the cathode of the rectifier tube is moved to ground and the other lead is placed on the screen grid of the 6A8G (pin No. 4), you will get a check from ground through R7 and R4. The circuit continuity of the remaining plate and screen grid circuits may be checked just as outlined for the others, no matter whether a resistor or coil winding is included.

The low voltage or control grid circuits may be tested in the same general way, and the method applies to all radio sets. For instance, in Fig. 11 connect one of your test leads to the center tap of the high voltage winding. Connect the other one to the control grid of the RF 6K7G tube. If the neon bulb lights, it means you have a complete circuit. If it does not glow, some unit along the circuit is open and an individual test on each unit will show where the fault lies. This test includes L1, R1, the two R8 resistors and T5. The same test from the control grid of the 6A8G tube will test the same circuit minus R1 and L1.

A connection from the control grid of the IF 6K7G tube to its cathode will give you a check on the secondary winding of T1 and R7 of the cathode circuit. Likewise, a connection from diode plate No. 1 to ground will give you a check on the secondary winding of T2, R4 and R9. No glow of the neon bulb means an open and you will know to make separate tests on the individual units.

Every other part and circuit in this and all other radio sets may be checked in a like manner for circuit continuity. If in doubt about a circuit or part, stop and disconnect it or isolate the part in some other way, and then make your tests.

Demonstration No. 61

HOW TO TEST TUBE FILAMENTS FOR CONTINUITY

A common trouble for A.C.-D.C. sets is burned out or open tube filaments. Since pilot lights and voltage regulators (ballast resistors) are often in series with filament circuits, these, too, may be

considered to be a part of the filament circuit. Thus, when tubes fail to light in an A.C.-D.C. set, one of the first things you want to check on is the possibility of an open. This test may be easily made with the neon bulb tester and the defect traced to its exact position in the series string. To make this test, disconnect the radio to be tested from the power line. Then turn on its switch and test across the power line contacts. If the bulb lights, there is no open (assuming there are no parallel circuits), but if it does not light, you may be sure there is an open somewhere along the series string. To find it, test one element of the circuit at a time including the switch and ballast or line cord resistor. First, test the line cord, then the ballast or line cord resistor, next the switch, then the pilot light and, finally, the tubes. To test the pilot light and ballast resistor all you have to do is to connect your test leads across their terminals—no light of the neon bulb means an open.

To test the tube filaments for continuity, remove them from their sockets and apply your test leads across the filament pins (the exact number of the pins will depend on the tube type). No light of the neon bulb means the filament is burned out and the tube should be replaced with a new one. In making this test, be sure your test is made across the proper terminals because tube pin unmbers vary for different types of tubes. You need not be concerned about the high voltage used to test the tube filaments. The resistor and neon tube will limit the current flow so no damage can be done to the filaments.

Demonstration No. 62

USE OF NEON BULB TO INDICATE VOLTAGE

In the absence of a voltmeter, you can use a neon bulb to indicate the presence of voltage. In this case you do not use your radio set to provide power for the neon bulb. *Instead it is obtained from the receiver under test.* To make this test, connect the B+ and ground leads of Fig. 10 together. *The test circuit now becomes a series voltage indicator.* To make the test for the presence of voltage at tube sockets, turn on the power to the receiver you are going to test. Then connect one of the test leads of Fig. 10 to the chassis of the receiver under test. Touch the other test lead to each of the plate and screen grid terminals of each tube socket in the set. If voltage is applied to the tube terminals under test, the neon bulb will light. If it does not light, it means you have no B+ voltage applied to the circuit under test. Make a note of how many of the circuits show this effect. Then rearrange your neon tester back into a continuity tester as per Fig. 10. Next check back over the various circuits of the radio under test *in which there was no indication of voltage.* Test every unit in the circuit for continuity from the tube socket terminals back to the filament or cathode of the rectifier tube. Be especially on the watch for open coils, open resistors and shorted filter or by-pass condensers which are usually connected across B+ circuits.

If you do not find the trouble in

the B+ circuits, check the cathode side of the circuits from the cathode terminal at the tube sockets on through resistors and other units back to the most negative point in the circuit. This is usually the center tap to the high voltage winding of the power transformer. Such a carefully detailed unit for unit test will positively enable you to find the cause of no voltage at the tube sockets.

Demonstration No. 63

OPEN PLATE CIRCUITS

Every tube plate circuit is subject to opens and many of them do open during the lifetime of a receiver. The open usually occurs in the plate circuit load, although it may occur in a voltage reducing resistor feeding the plate circuit. Plate circuit loads consist of resistors, AF choke coils, RF and IF coil windings and AF transformer windings. When they open, no voltage is applied to the plate of the tube which means the signal circuit is interrupted and, therefore, no sound is reproduced. The remedy, of course, is to replace the open unit. The open condition is arrived at by first determining that no voltage is applied to the tube socket plate terminal. This is established by means of the neon bulb as explained under demonstration No. 62. The actual open unit is then isolated by means of continuity testing as already explained.

You can simulate open plate circuit conditions in any receiver by disconnecting the wire at the plate terminal of the tube sockets. Note this interrupts the circuit completely. Do this and make a test to prove that no voltage exists at the plate terminal of the socket.

Demonstration No. 64

SHORTED PLATE CIRCUITS

Plate circuit shorts are, in most cases, a condition of the plate circuit becoming grounded—that is, they are, in effect, caused to come into direct or indirect contact with the receiver chassis or a metal object at ground potential. Thus, a plate circuit exposed lead can be shorted (mostly due to accident) to another part of the circuit and then give the effect of a direct short circuit. The more common cause for this trouble, however, is a by-pass or filter condenser puncturing (short circuit from plate to plate) and thus, in turn, short circuiting the B+ voltage to ground or to the chassis. If the puncture of dielectric is complete from plate to plate of the condenser forming a circuit of little or no resistance, the plate voltage becomes fully shorted or shunted away from the plate terminal at the tube socket. If the puncture of the dielectric is partial, it will form a parallel path of considerable resistance, and the voltage at the plate of the tube will be reduced in proportion to the amount of resistance formed by the partial short circuit. Regardless of whether the condenser is completely or only partially shorted, it must be identified as such and then replaced with a suitable condenser.

A quick test at the plate terminal of each tube socket will show up a direct short circuit. Use the set up described under demonstration No. 62 as a voltage indicator. If you find little or no voltage at one or more tube sockets, trace back over the circuits involved and test each by-pass filter condenser as

you come to it. If they show signs of partial or complete short circuits disconnect the condensers from the circuit and again test for voltage at the tube sockets. If voltage is restored, you have further proof that the condensers under suspicion are shorted and need replacing. Disconnecting one or more condensers from a receiver may increase the normal hum, but this will do no harm as proper replacement condensers will correct this condition. In interpreting the no voltage condition at the tube socket plate terminals, be careful and do not confuse this with an open plate circuit continuity test as explained under demonstration No. 63. If you prove that an open does not exist, then a lack of plate voltage is more than likely due to a short circuit, and this may, in turn, be due to the condition of a plate by-pass or filter condenser in the power unit.

Demonstration No. 65

OPEN GRID CIRCUITS

When reference is made to a grid circuit, the signal or control grid is usually referred to. It is the grid to which a negative voltage is usually applied. This grid circuit extends from the usual control grid connection at the tube socket through the grid load (usually a coil or resistor) back to B negative or ground. In RF and IF stages, this usually includes AVC filter resistors such as R1 and R8 of Fig. 11. Before it gets back to ground or B negative, it may go through one or more bias resistors such as R2 of Fig. 11. In other cases, the grid circuit connects to ground after it leaves the load. The grid return of the 6A8G and the 6K7G (IF) in Fig. 11 are examples of this type of connection. The 6F6G grid return in Fig. 11 is an example of a more complex circuit. Here, the path of the circuit is through the two R13 resistors, through T5 and R2 before ground is reached. Regardless of the circuitous route that a grid circuit may take, it is subject to opens and a test of its entire length must be made to establish continuity.

Since the voltage in most grid circuits is low and negative in polarity, it is best to test the continuity of the circuit rather than attempting a voltage test. To make this test, set up your continuity tester in the usual way. Then using Fig. 11 as an example, place one test lead on the control grid of the 6G7G RF tube and the other one to ground. If the neon bulb lights, it proves that you have circuit continuity through L1, R1, R8 and R2. A test from the control grid of the 6A8G tube to ground would give a test over the same circuit but omitting L1 and R1 and including the secondary winding of L2. A test from the 6K7G IF tube control grid to ground checks the continuity of the secondary T1. The 6Q7G tube includes two diode plates. A test from one plate to ground would check the continuity of the secondary T2, R4 and R9, while a test from the other diode plate would check R8 and R2. For the control grid of the 6Q7G tube, a test from it to ground would indicate the continuity of R10. The remaining control grid circuit of Fig. 11 is for the 6F6G tube. A test from it to ground would indicate the condition of the two R13 resistors, T5 and R2.

The continuity of all other control grid circuits for other receivers would be tested in a like manner. Merely test from the control grid to ground and then examine the diagram of the set or trace the actual wiring to see just what units are included in the test.

Now consider cases where *no continuity* is indicated. No matter what kind of control grid or diode plate circuit is involved, the procedure is the same in every case. No light of the neon bulb means at least one of the units in the control grid circuit is open. To determine which one is open, merely place your test leads across each unit in the control grid circuit. For example, consider the control grid circuit of the 6K7G RF tube in Fig. 11. To find out which one of these units is open, first test across L1, then R1, next the two R8 resistors, and finally, test across R2. Testing across a unit merely means placing one test lead on one terminal or lead of the unit and placing the other test lead on the remaining terminal or lead of the unit. If an open was previously indicated for the entire circuit, then a detail test unit for unit in the circuit as outlined will indicate which unit is open. A light of the neon bulb means the unit has continuity—no light means it is open.

There is one other precaution you must observe when testing the continuity of control grid circuits to ground. That is, you must not let a shorted condenser deceive you. For instance, consider condensers like C2, C7 and C8 of Fig. 11. If they become shorted (which can happen but rarely does), then the remaining part of the circuit is also shorted out of the circuit. Thus, you may get an indication of continuity which will be true, *yet it will be through the shorted condenser.* This automatically omits a test on the remaining part of the circuit which is shorted out due to the condition of the condenser.

Since these and similarly connected condensers are in reality in shunt (parallel) to the control grid circuit, the neon bulb is going to light to a certain degree because of the shunt path. *Make it a rule, therefore, to disconnect all condensers which shunt a circuit before you test it for continuity.* Then test the circuit as described and before reconnecting the shunt condensers, give them a test so you can prove they are neither shorted or open.

Demonstration No. 66

OPEN SPEAKER CIRCUITS

The usual speaker includes a field coil winding and a voice coil winding (see your lesson on speakers). If the field coil opens, it usually interrupts the B+ circuit and while very high voltage may be applied to the output tube or tubes, there is usually no voltage applied to the other tubes in the receiver. If the voice coil opens, there is no sound from the speaker—not even the low hum level—but voltages throughout the receiver will be normal. These are symptoms, and if you observe them in a given receiver, be sure to check the condition of the speaker.

To check the speaker, disconnect or unplug it (depending on the design) and test both the field and voice coil for continuity. With the speaker disconnected, the field coil

terminals are usually readily available. For the voice coil, however, you will probably have to open the circuit to make a test. To do this, unsolder one voice coil lead at a convenient point. Then connect your test leads in series with the two points made available by opening the circuit. A light of the neon bulb means no open is present—no light means an open and the speaker or its voice coil will have to be replaced. In case there is no open, resolder the voice coil to restore continuity.

Demonstration No. 67

HOW TO TEST FOR OPEN COUPLING CONDENSERS

A coupling condenser is one connected between the plate of one tube and the grid of the following tube. Its purpose is to transfer the signal from one stage to another. There are two such condensers in Fig. 11—these are C1 and C5. C1 couples the signal from the diode load circuit to the triode grid of the 6Q7G. C5 couples the signal from the plate of the 6Q7G. Condensers of this type are very critical in operation and will tolerate little leakage. If excessive leakage develops, distortion is sure to be present and the grid voltage of the tube following the coupling condenser will be affected. These condensers may also develop *opens*, causing no signal or there may be an intermittent type of trouble with the signal stopping and starting for no apparent reason. In this case, the D.C. voltage throughout the receiver is not likely to be affected. This type of trouble can be very elusive because no outward clues are usually present. So when you observe the general symptoms as outlined above, be sure to test the coupling condensers.

To determine the condition of coupling condensers with your neon bulb continuity tester, proceed as outlined under demonstration No. 59. Make tests for both opens and shorts. Replace any coupling condenser you may *suspect* on general principles.

Demonstration No. 68

GROUNDED CIRCUITS

The distinction between a grounded circuit and a short circuit is not very clear. Many times both terms are used to denote the same thing. For instance, if the screen grid by-pass condenser C20 in Fig. 11 punctures through from one set of plates to the other, these plates become shorted and the screen grid circuit becomes grounded through the shorted condenser. Thus, we have both a short circuit and a ground. Either term therefore, would describe the condition.

What we are most interested in under this demonstration is a direct ground not involving a short circuit, such as that of a condenser. A direct ground can be caused where a tube socket terminal touches the metal chassis, where a coil terminal, gang condenser terminal or other parts touch or come in contact either with the chassis or some other metal part. Such grounds are usually accidentally caused by moving the wiring or brought about by expansion caused by heat. Then again a small piece of solder or other short length of wire or metal can work itself due to vibration under a terminal and

so short it to the chassis.

Where you have reason to think such a ground exists (where, for instance, there is no plate or screen grid voltage on a tube, and you prove there are no opens or shorts), then make a check for grounds. To do this, disconnect the terminal under suspicion from its normal connection or connections, and then make a continuity test between the terminal and the ground. A light of the neon bulb indicates the terminal under test is grounded. Be careful in making this test to see that a parallel path to ground does not exist and in that way show a grounded circuit where none really exists. Sometimes you can make a visual test of a terminal under suspicion and determine whether it is grounded. This would be particularly true for a tube socket, coil or switch terminal.

Demonstration No. 69

GANG CONDENSER SHORTED

Practically every radio set includes a gang condenser and all of them are subject to full shorts or intermittent shorts. The condenser plates may warp or become bent or even collect dust and dirt particles and thereby become shorted. If the plates are fully shorted, no signal at all will be noticed. If there is a partial short or dirt and dust collected between plates, there will be scratching noises as the tuning control is rotated. It is a good idea to always clean dirt and dust from between tuning condenser plates where you notice it has collected. This may be done by inserting a tobacco pipe cleaner between the plates or using a blast of air from the hose of a vacuum cleaner.

If you suspect a tuning condenser, disconnect its stator plate connections and connect one of your test leads to the common rotor terminal or to ground. Then, in turn, place the other test lead on each of the stator terminals and turn the tuning control through its length of rotation. If the neon bulb lights when this is done, you have a short circuit. If this cannot be done, the only other alternative is to replace the tuning condenser. This same general test may be made on all types of radio sets.

Demonstration No. 70

A.V.C. CIRCUIT DEFECTS

The A.V.C. circuit in all radio sets is a delicately balanced system. In the main it consists of a network of resistors and condensers, usually starting at the diode load and ending at the grid returns of one or more tubes. The A.V.C. action is based upon the time constant of a combination of resistors and condensers. These units are subject to opens and shorts and should have values reasonably near those called for by the diagram. The condensers particularly should be in good condition and have little leakage. An A.V.C. circuit with wrong values usually causes oscillation and reproduction in general is distorted. Where the circuit is seriously interrupted as, for instance, an open resistor or shorted condenser, there will be no A.V.C. action at all. Fading will be more noticeable and there will be loud blasts or increases of volume from the speaker.

Whenever A.V.C. trouble is suspected a detailed check should be made on every part of the A.V.C.

system, including the tube which develops the voltage. In a circuit like Fig. 11 where two diode plates are involved, the A.V.C. circuit consists of the filter resistors R8 and R1, and their filter condenser C2 in one branch and the other R8 resistor and R2 resistor in another branch. In other A.V.C. systems, the diode load resistor and its associated condensers are likely to be a part of the A.V.C. system. Regardless of the arrangement, all condensers and all resistors should be checked most carefully. Use your neon bulb continuity tester for tests, just as you would test other resistors and condensers. See demonstrations No. 58 and 59.

Demonstration No. 71

HOW TO TEST TRIMMER AND PADDER CONDENSERS

Trimmer and padder condensers do not usually give trouble unless an inexperienced person tampers with them. Sometimes the owner of a radio set will turn the adjusting screws back and forth so many times that screw threads are worn or the insulation between plates is cracked or broken. Worn threads can be determined from visual observation or you may notice the condenser will not hold its tuning adjustment for any length of time. In either case, where such a mechanical defect occurs, the trimmer or padder condenser should be replaced.

To check for cracked insulation or leakage in a trimmer or padder, the best procedure is to disconnect all leads from the circuit no matter if it is an RF, oscillator or IF condenser. Then connect your neon bulb tester across the condenser terminals, turn the adjusting screw all the way to the right, and left, and watch the neon bulb. If it lights intermittently or stays lit with a *full glow,* then the condenser under test should be replaced. The bulb may light faintly, due to the capacity of the condenser. However, disregard this as it will be a normal action.

Demonstration No. 72

HOW TO USE YOUR RADIO AS A TWO BAND OSCILLATOR

If you do not have a test oscillator or signal generator you may arrange your radio as one. This will cover the broadcast band (550 to 1600 KC) and one short wave band (from about 5 to 18 megacycles). If you decide to make this change you cannot use your radio as a receiver. So you will have to decide whether you want to use the radio as a tester or as a receiver.

The 12SK7 RF tube is used as a modulator and the 12SA7 as an oscillator or converter. The remaining portion of the receiver may be used as a tester and for signal tracing as will be explained later. The new arrangement for the circuit is shown in Fig. 12. Most of the original parts may be used, but you will need a few additional parts and these may be obtained from any radio parts jobber or from radio mail order firms. The new parts you will need are 500,000 and 150,000 ohm ½ to 1 watt resistors and a ¼ to ½ watt neon bulb.

To arrange this circuit, first remove the antenna coil and the connections to it as these will not be needed. Also remove the IF wave

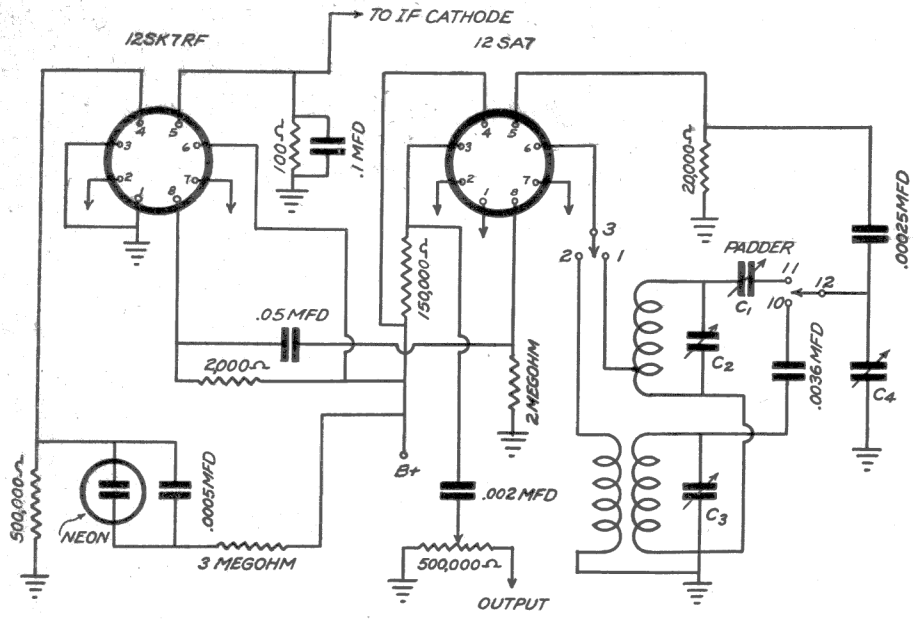


FIG. 12

trap (02866) and the coupling coil (02864) and the .0005 mfd. mica condenser across it from between the RF and oscillator tubes. Remove the two terminal tie lug where it is mounted at the 35L6 socket and remount it with the mounting screw of the 12SK7 RF socket nearest the end of the chassis—in this new position, it will serve as a mounting for the neon bulb. Next remove all connections from the volume control except the grounded connection—also, remove the .00025 mfd. condenser from the volume control.

Connect a 500,000 ohm fixed resistor from No. 4 of the 12SK7 RF socket to ground. The neon bulb should next be mounted onto the two terminal tie lug near the 12SK7 RF socket. The exact mounting procedure will depend on the type of neon bulb you get. We used the ¼ watt type with a screw base. This means a socket should be used for the bulb. These bulbs are made to fit either a screw or bayonet type base, or you may be able to get a ¼ watt neon bulb with wire leads on the end of the glass bulb. In any event, solder either one terminal of the bulb socket or one wire lead of the neon bulb to the insulated terminal of the two terminal tie lug which you have mounted on the 12SK7 RF socket. Next remove the 3 megohm resistance from the three terminal tie lug (or use a new one as brought out later on) and reconnect one end of it to the same terminal of the two terminal tie lug to which you have connected the neon bulb. Connect the other end of the 3 megohm resistor to No. 6 of the 12SK7 RF socket. In the receiver circuit, a .0005 mfd condenser was connected between the coupling coil (02864) and No. 8 of the 12SA7 socket. Reconnect this mica condenser across the termi-

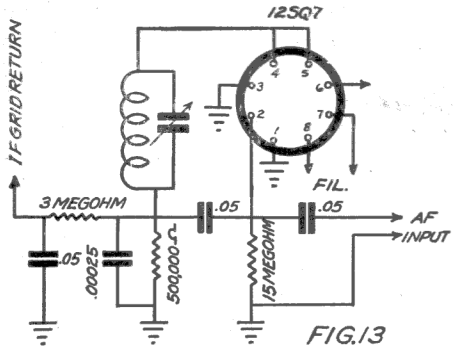


FIG. 13

nals of the neon bulb as in Fig. 12. The 2000 ohm resistor is already connected to No. 8 of the 12SK7 RF tube so you will not need to reconnect it. Next you will need a coupling condenser from the plate of the RF tube to the No. 3 grid of the 12SA7. For this purpose, remove the .05 mfd. condenser from No. 3 of the 35Z5 socket and reconnect it between the No. 8 terminals of the 12SK7 and 12SA7 sockets. The 100 ohm resistor and .1 mfd. condenser is to be left connected to the No. 5 terminal of the 12SK7 RF socket with a wire lead connecting to No. 5 of the 12SK7 RF socket as indicated in Fig. 12—this resistor will still act as a bias for the RF and IF tubes.

Next connect a 150,000 ohm resistor from B+ to No. 3 of the 12SA7 socket. Next note that one end of the .002 mfd. condenser is already connected to the center terminal of the 500,000 ohm volume control—connect the other terminal of this condenser to No. 3 of the 12SA7 socket. Next connect a length of wire about 2 feet long to the ungrounded terminal of the 500,000 ohm volume control—this will become the output lead for your signal generator. Note that one terminal of the volume control is grounded. The 2 megohm resistor is to remain connected to No. 8 of the 12SA7 socket. Likewise, you do not have to disturb the connections to Nos. 1, 2, 4, 5, 6 and 7 of the 12SA7 socket.

The tuning condenser gang is operated as a single unit for the oscillator application. Thus you should connect the free stator terminal of the gang condenser (formerly used to tune the RF) to No. 12 of the selector switch. This connection will connect both sections of the gang condenser as one unit so that both of them may be used to tune the oscillator coil. Note in Fig. 12, C_1 is the padder condenser for the oscillator, C_2 is the trimmer for the broadcast band, C_3 is the trimmer for the short wave band and C_4 represents both sections of the gang condenser. C_1, C_2 and C_3 may be adjusted just as for receiving purposes. Note the input IF transformer (01706) is no longer to be connected to the 12SA7 tube—the 150,000 ohm resistor forming the plate load for the 12SA7 tube.

Because of its arrangement, this oscillator will give a broad signal. This is because the original design of the radio set did not require that it be well shielded. If you wish to cut down on the total radiation of the oscillator, additional shielding may be added to the chassis which will greatly aid in obtaining a better control of the signal. Perhaps the easiest way to accomplish this is to take the chassis to a sheet metal or tin shop and get them to cut and fit sheet metal to fit the bottom and ends of the chassis. This will cover all exposed wiring and prevent excess radiation

thereby giving a better control of the signal by the output attenuator.

The tone of the modulation in Fig 12 can be changed materially by using different values for the condenser across the neon bulb and for the 3 megohm resistor in series with the bulb. Values for the condenser may vary from .001 to .0005 mfd. and from 300,000 ohms to 3 megohms for the resistor. We found .0005 mfd. and 3 megohms to give a very satisfactory signal. The selector switch will control the circuit as before for short wave and broadcast band operation.

When you have the circuit completely wired turn on the switch (with all tubes in their usual sockets) and connect the R. F. output lead to the input of another set. A convenient way to make this connection is to twist your output lead a few turns around the input lead of the radio set under test. The insulation between the two wires will allow a small coupling capacity to be formed. This will provide ample coupling between the output of the test oscillator and input of the receiver.

Next set your test oscillator dial to about 1400 KC and tune in the signal it provides on the radio set under test. If the test oscillator and radio under test do not agree (meaning reproduction of the test oscillator signal in the radio under test) as to the approximate same dial readings, reset the dial or tuning scale of the radio under test to exactly 1400 KC. Then readjust the test oscillator tuning control, first in one direction and then the other from its original position at the same time varying the gang condenser trimmers slightly. The object of this is to get the test oscillator and radio under test to agree to the same tuning scale reading. This is called calibrating the test oscillator—it enables you to prove that it is actually producing a test signal at a frequency corresponding to the dial reading. If, in making this adjustment, the reproduction from the radio set under test is too loud, you can reduce it to a comfortable level by reducing the R. F. output control or reducing the volume control of the radio set under test.

When this calibration is completed, your test oscillator is ready to be used on any other radio set for the broadcast band, just as you would use any test oscillator or signal generator. See lesson S-4, S-5 and S-6.

Demonstration No. 73

HOW TO MAKE I. F. ADJUSTMENTS

The test oscillator described in the foregoing demonstration is not an I. F. oscillator as the term is usually understood. Nevertheless, I. F. adjustments may be made with the aid of it if you are careful. The average well experienced radio serviceman can adjust all tuned circuits of the average radio set without the aid of a test oscillator or signal generator. In lieu of the necessary test instrument, a broadcast signal is used. This method does take longer and a little more patience is required, but it can be done. Assuming you are not well experienced, it may take you a little longer by the same method, but the fact remains, you can do it.

Your problem is not nearly so complicated ,however, because you will have a broadcast band test signal of fixed intensity if you arrange your radio receiver according to the previous demonstration. To illustrate the principles involved, suppose we assume you have a superheterodyne radio set which needs an overall tuning adjustment. Furthermore, let us assume it is so far out of adjustment that no signal at all can be received. To begin the work, couple your test oscillator to the receiver and tuned both to about 1200 KC. Set the output control on your test oscillator to maximum and turn up the volume control on the receiver to maximum. Next, locate the R. F. and oscillator trimmers on the radio set you are adjusting. When you have done this, turn them down tight and then turn them back in the opposite direction one full turn. This will not give you perfect alignment of the R. F. stages, but it will probably be near enough to pass through the stages at least a small amount of R. F. energy.

Next, locate all the I. F. trimmers. When you have done this, turn them all the way to the right and then back off one full turn. If iron core variable trimmers are in use, set the adjusting screws to about the same relative position. This and the foregoing R. F. adjustment is simply a preliminary adjustment, the object being to get some kind of signal through the set. If, on this first try, you do not get a signal, then adjust your test oscillator tuning control back and forth about 200 KC on each side of 1200 KC. This very probably will at least allow a faint signal to get through the tuned stages. If it does not, reset your test oscillator to 1200 KC. and then vary all trimmers (both R. F. and I. F.) from left to right over a wide range. If you do not get a signal, return each trimmer to its original setting and go on to the next one to repeat the operation.

If this procedure is followed carefully, step by step, you will finally hear the signal from the test oscillator reproduced from the speaker in the receiver under test. No matter when this occurs, stop whatever you are doing and adjust all I. F. trimmers for maximum volume. It does not matter whether you have hit on the correct I. F. frequency or not—the main point being that you want to get all of them aligned at one and the same frequency. Later when other adjustments have been made, you can check on whether or not you have aligned at the correct I. F. frequency.

We assume now that you have the I. F. aligned for maximum volume at some unknown frequency. The next step is to return to the R. F. and oscillator stages and align them for maximum volume by turning the trimmers to the right or left. If the reproduction from the speaker becomes uncomfortably loud, reduce either the test oscillator or receiver volume control or both for comfortable volume level.

The next step is an important one and determines whether or not your adjustments have been made somewhat near the correct frequency. Retune both receiver and test oscillator to about 600 KC and

turn up the test oscillator and receiver volume control to maximum. If you hear the test oscillator signal, this time, you have made the approximately correct frequency adjustment on the I. F. and R. F. stages and only an overall finer adjustment is all that is required to complete the job.

On the other hand, if you do not hear a signal at 600 KC, retune your test oscillator about 100 KC each side of 600 KC—that is, down to 500 KC and up to 700 KC. If this enables you to hear the signal, locate the 600 KC padding condenser on the receiver under test and adjust it for maximum volume. When this is done, start to slowly move the test oscillator tuning control towards 600 KC. At the same time keep the 600 KC padder in step with the tuning by turning it in whatever direction is required to maintain the sound of the test signal in the speaker. In this way, you can shift the point of maximum volume from, say, 650 KC to 600 KC or from 550 to 600 KC. There is no trick at all to this particular setup and you will soon be able to master it with a little practice.

With the 600 KC adjustment made to the best of your ability, disconnect your test oscillator from the set under test. Then cut off its power altogether so its signal will not interfere with the radio set you have adjusted. Next tune the radio set over the entire band. If you receive signals from radio stations at the approximately correct frequency *without squeals and howls* and receive them over the entire band (taking into consideration your location and the stations that are usually received on other receivers) then your overall tuning adjustment has been correctly made.

Don't be discouraged, however, if your adjustment has not been correctly made. The chances are it will not be correct on the first try, particularly if you have had little or no experience with tuning alignment. If you find you do not have the correct adjustment, go back over all trimmers and readjust them for maximum volume, beginning with the one preceding the 2nd detector and working back over all of them until you come to the one in the R. F. or antenna stage. Then adjust the 600 KC padder at 600 KC for maximum volume. On this second overall adjustment you may use your test oscillator or a broadcast signal as a signal source.

Now let us go back where mention was first made of the 600 KC trimmer—at the point where you were first trying to hear a signal at or near 600 KC, using this experimental method of adjusting the correct IF frequency the chances are on the first try you will not hit on the correct I. F. setting and, as a consequence, you may not be able to tune in a signal at or even near 600 KC. This is a definite indication that you do not have the correct adjustment either for the RF or IF. From this point on, you must have patience and try to remember everything you have learned about overall adjustments. Before tampering with your overall adjustments, first tune in several stations of known frequency. Note how far off they are in frequency with re-

spect to the dial reading. For instance, suppose you receive a 1300 KC signal from a radio station at 900 KC on the dial. This is a 400 KC diffrence, and it means your adjustment is considerably off. To get the correct adjustment, couple your test oscillator to the set under test and set it to 1300 KC. Adjust the radio set tuning control until the signal from the test oscillator is tuned to maximum volume—according to the foregoing conditions, it should be received at about 900 KC because you proved this much frequency difference existed when tuning in the 1300 KC broadcast station. The next step is to turn the receiver tuning control from 900 KC towards 1300 KC until the signal can just barely be heard. Stop at this point and readjust all I. F. and R. F. trimmers until the signal can again be brought up to maximum volume. Then turn the tuning control of the radio set again towards 1300 KC until you again come to the point of *minimum* voume. Stop here and readjust all I. F. and R. F. trimmers to maximum volume. Continue this procedure in steps until you get the trimmers adjusted to maximum volume at exactly 1300 KC. In this way you will adjust for difference of frequency and will make the receiver dial match with the actual tuning alignment.

When you have made such an adjustment as the foregoing, next reset the tuning controls to 600 KC and almost invariably you will find the signal can be heard this time at about the correct point on the dial. Adjust the 600 KC padder as previously directed, and then return to the I. F. and R. F. for a final overall adjustment, using a test frequency of about 1300 KC to 1500 KC.

If, in making your final adjustments, you hear the signals of a strong local station, do not pay any attention to this but depend on your test oscillator signal entirely. A good general rule to always follow in making tuning adjustments is to select a test frequency where no local interference from broadcast signals is present.

The complete tuning procedure as outlined may appear involved and complex at first, but it is really simple once you get on to it and is just as reliable as when using a good calibrated I. F. signal generator. It does take time to make the various adjustments, especially for a beginner, but this should largely be made up for when you get more experience.

Demonstration No. 74

HOW TO MAKE AN IF SIGNAL TRACER

The first two stages of your radio are in use as an oscillator. The remaining stages may be used as IF and AF signal tracers. The blue and red leads of the input IF transformer may be used as the two input leads of your IF signal tracer—these leads should be brought out or extended to convenient connecting points on the chassis. You may use tip jacks or binding posts for them. Thus this input IF circuit can be substituted for another tuned to 456 KC in other 456 KC receivers you might be testing. The grid return of the 12SK7 IF tube is incomplete because you used the 3 megohm resistor (which was connected in se-

ries with it) in the 12SK7 modulator circuit. Any other resistor from 500,000 ohms to 3 megohms may be used in place of the original 3 megohm resistor, or, if you prefer, let the original resistor remain at this point in the circuit and use a new 3 megohm resistor in the modulator circuit. Your lessons S-29 and S-30 give the details of signal tracing, and you should have no trouble in using your *tester radio* as an IF signal tracer as described in the two lessons. The AF section of your *tester radio* may also be used as an AF signal tracer as will be described, but both the IF and AF sections cannot be used at the same time since the speaker becomes the output indicator in both cases—that is, for both IF and AF tests.

Demonstration No. 75

HOW TO MAKE AN AF SIGNAL TRACER

Since the 500,000 ohm volume control was removed from the diode circuit another resistor will be required to take its place. The new circuit arrangement is shown in Fig. 13. Note the circuit is very similar to the original with a fixed 500,000 ohm resistor taking the place of the original volume control. You will need a new .05 mfd. condenser to take the place of the original .002 coupling condenser. Note, too, an extra .05 mfd. condenser is added to the circuit for an AF input. This becomes the input lead to the AF signal tracer—a ground wire or lead being used for the other AF input. Two test leads may be connected to these two points for the AF input if desired. The primary of the IF transformer remains connected to the IF tube as before. It is not necessary to disturb the remaining connections to the 12SQ7 and 35L6 tubes.

Demonstration No. 76

HOW TO USE AN AUDIO SIGNAL TRACER

An audio signal tracer works on the principle that it will pick up and amplify any A. F. signal, provided it is properly coupled to it. The test lead and .05 mfd. condenser referred to in the previous demonstration provide the necessary coupling. To use it all you have to do is turn on your radio test set and connect the AF test lead to various points in other A. F. systems—this may be part of a radio set or complete A. F. amplifier, such as in Public Address systems, Juke Boxes or Motion Picture Amplifiers.

We will not attempt to go into the theory of audio signal tracers here because it is adequately covered in your lesson S-30. The general point is that in an A. F. circuit like that of Fig. 11 of this lesson, it is possible to quickly tell if a certain part is functioning properly by determining if A. F. exists across it. The speaker of your tester reproduces the sound, and it acts as the indicating device.

For instance, suppose the A. F. system in Fig. 11 is not passing an A. F. signal. You would begin testing each part by placing your A. F. test lead between R4 and R9, then C1 and R10 and on to the triode grid of the 6Q7G through to the speaker circuit. If you failed to pick up an A. F. signal along the route, you should stop at that point and test all parts for defects.

You would need to check on the condition of tube or tubes and check all resistors, condensers, transformers and chokes (if they are used in the A. F. system) for opens, shorts and wrong connections. Your continuity tester could be used for this purpose. Refer to your lesson S-30 for more specific tests when using an audio signal tracer.

Demonstration No. 77

HOW TO TEST TUBES

It was mentioned under demonstration No. 61 how to test tube filaments for continuity. This test is important for A. C.-D. C. radio sets where tube filament burn outs are common. The test is equally applicable to all types of tubes. In the test about to be described, tubes may be tested for amplifying, detector and rectifier ability, or for whatever other function the tube may be called upon to perform. The procedure is simple and positive in its results.

To carry out this test on a given radio set, couple your test oscillator to it and tune in the test signal at about 600 KC. Reduce the output control of the test oscillator and the volume control of the radio under test until the signal can be barely heard. Now try *new tubes one at a time* in the radio set under test. Allow time for the tube to reach proper operating temperature. If substituting a new tube for an old one causes the volume of the radio set to perceptibly *increase* then you can safely assume a new tube is needed in the socket where the new tube has been inserted. The same test may be made on all tubes in the set, regardless of their types.

Of course, a manufactured tube tester will make these tests more conveniently and faster. But if such a tester is not readily available to you, this is one way how tube tests may be made. If, on the other hand, new tubes cannot be obtained for a comparison, the only other way to test the condition of doubtful tubes is to take them to a radio store, service shop or jobber where manufactured tube testers are available.

Demonstration No. 78

TRACING FOR HUM IN AUDIO SYSTEMS

It often happens that an audio system will develop hum, due to the partial failure of one or more parts—for instance, a leaking condenser, a defective tube, intermittent ground, etc. Rather than go through a complete system and test all parts, it is often convenient to locate the hum to one stage. This can be done by temporarily shorting the primary of the output transformer and using your audio signal tracer to test plate and grid circuits. To short the output transformer, merely connect a short piece of wire across its terminals or wire leads. The object of this is to prevent the speaker of the receiver under test from reproducing the hum.

Next, take your audio signal tracer and connect its input lead at the point where AF is first made available in the set under test. If you hear hum at this point, it is originating in the detector stage or it is coming in on the RF carrier, which suggests the hum cause

is in the RF or IF part of the circuit. In this case, tests for defects must be confined to the RF and IF stages.

On the other hand the hum may originate in succeeding AF grid or plate circuits. To check this, touch your AF signal tracer lead to all grid and plate terminals in the AF system. If, on doing this, you find hum to be suddenly reproduced in the speaker of your signal tracer, you will know you have located the stage in which it originates. A careful check on all parts making up the stage should enable you to find the exact cause of the trouble.

Of course, there are conditions in the power unit which can cause AF hum, such as defective rectifier tubes, open resistors and shorted filter condensers. These, however, make themselves evident in other ways such as a lack of voltage on the other tubes, etc. Thus, should this be true, you will be lead to the real source of trouble without having to make an AF stage test for hum.

Demonstration No. 79

HOW TO MAKE NEUTRALIZING TESTS

It is only the very old receivers and some few special circuits in modern receivers that require neutralizing adjustments. Your test oscillator can be used satisfactorily for this work. All you need to do is to couple your test oscillator to the input of the receiver in the usual way. Then insulate the filament or cathode terminal, depending on tube type—the object being to interrupt the flow of plate current and adjust the neutralizing condenser for *minimum* signals. See your lessons S-4, 5 and 6 for further details on neutralizing.

Demonstration No. 80

HOW TO IDENTIFY POWER TRANSFORMER TERMINALS

It often happens that a serviceman will have a power transformer with the terminals or wire leads unidentified. Before the transformer can be connected to a power unit circuit, its terminals must be correctly identified. As an aid to this identification, your neon bulb continuity tester may be profitably employed.

The first step is to identify terminals between which a winding exists. Connect one of your test leads to any one of the transformer terminals and keep it there for the time being. Then touch your other test lead to each of the other terminals. Unless a winding is open or burned out, you will find out that the neon test bulb will light when you touch one or more of the terminals with your second test lead. This indicates that a winding exists between the two terminals across which your test leads are connected. Tag these two terminals for identification and proceed to test between all the other terminals until you have all terminals tagged and identified.

It is well to keep in mind the physical arrangement of most power transformers. Most transformers which you will need to test by this method will be of the full wave type. Thus, the high voltage secondary will have three common terminals—one the center tap while the other two are for the ends of the winding which will go to the

plates of the rectifier tube. Wire for this winding will usually be smaller than for any other winding of the transformer.

The primary winding will have at least two terminals and there may be three or more—representing taps for different line voltages. The usual power transformer, however, will only have two terminals for the primary. The wires for this winding will be of medium size in relation to the other windings.

The low voltage secondaries may have as many as three terminals—one for a center tap connection—but probably will have only two terminals. The wire for these windings will be larger in size than for any of the other windings.

For the usual power transformer there will be at least two low voltage secondaries and perhaps more. One will be for the rectifier tube and one or more for the filaments of the other tubes. There are cases where one low voltage filament winding will serve for all tube filaments.

If the transformer employs colored leads, it will probably conform to the R.M.A. standard color code for power transformers. The following table gives identification for this code.

COLOR CODING OF LEADS—RADIO POWER TRANSFORMERS

It shall be standard to use the following color code for power transformer leads for radio receivers:

Primary Leads.....black
If Tapped—Common.....black
—Tap..black & yellow striped
—Finish....black & red striped
Rectifier—Plate Winding.....red
Center Tap.....red & yellow striped
Rectifier—Filament Winding.....yellow
Center Tap.....yellow & blue striped
Amplifier—Fil. Winding No. 1.....green
Center Tap.....green & yellow striped
Amplifier—Fil. Winding No. 2.....brown
Center Tap....brown & yellow striped
Amplifier—Fil. Winding No. 3.....slate
Center Tap....slate & yellow striped